Product User Manual for the "Air Mass Analysis" product (AMA, PGE12, v2.1)

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The EUMETSAT Network of Satellite Application Facilities

NWC SAF

Support to Nowcasting and Very Short Range Forecasting

Prepared by ZAMG

REPORT SIGNATURE TABLE

Function	Name	Signature	Date
Prepared by	ZAMG		*8 September 2009*
Reviewed by	ZAMG		*8 September 2009*
Authorised by	Pilar Fernández SAFNWC Project Manager		*8 September 2009*

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Version	Date	Pages	CHANGE(S)
2.0	16 September 2007	23	Initial version (content derived from various precursor documents on PGE12, most notably "Software User Manual for the SAFNWC/MSG: Scientific part for the PGE12")
2.1	23 February 2009	25	Update for the SAFNWC/MSG release 2009, mainly on new quality flag
2.1.1	8 September 2009	25	Minor – mainly editorial - updates for the SAFNWC/MSG release 2010. No scientific updates.

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1. INTRODUCTION

The Eumetsat "Satellite Application Facilities" (SAF) are dedicated centres of excellence for processing satellite data, and form an integral part of the distributed EUMETSAT Application Ground Segment (http://www.eumetsat.int). This documentation is provided by the SAF on Support to Nowcasting and Very Short Range Forecasting, SAFNWC. The main objective of SAFNWC is to provide, further develop and maintain software packages to be used for Nowcasting applications of operational meteorological satellite data by National Meteorological Services. More information can be found at the SAFNWC webpage, http://www.nwcsaf.org. This document is applicable to the SAFNWC processing package for Meteosat satellites meteorological satellites, SAFNWC/MSG.

1.1 SCOPE OF THE DOCUMENT

This document is the Product User Manual for MSG Air Mass Analysis Products (PGE12).

This document contains practical information on the characteristics of the above mentioned products, on their applicability and limitations.

1.2 SCOPE OF OTHER DOCUMENTS

The algorithms used to extract the MSG Air Mass Analysis Products (PGE12) are detailed in an Algorithm Theoretical Basis Document (AD. 4).

The latest validation of the algorithms used to extract the MSG Air Mass Analysis Products (PGE12) is reported in a validation report (AD. 5).

Instructions to install, configure and execute the SAFNWC/MSG software in order to extract the MSG Air Mass Analysis Products (PGE12) are detailed in a Software User Manual (AD. 3).

The Interface Control Documents (AD. 1) (for the External and Internal Interfaces of the SAFNWC/MSG) and (AD. 2) (MSG Output Product Format Definition) detail the input and output data format for the SAFNWC/MSG software.

1.3 SOFTWARE VERSION IDENTIFICATION

This document describes the products obtained from the PGE12 version included in the 2010 SAFNWC/MSG software package delivery.

1.4 IMPROVEMENT FROM PREVIOUS VERSION

Minor technical updates to be compliant with the most recent NWCLIB data-type definitions.

1.5 DEFINITIONS, ACRONYMS AND ABBREVIATIONS

AMA	Air Mass Analysis
.cfm	PGE12 model configuration file (nominally at $SAFNWC/config/safnwc_pge12.cfm)
ECMWF	European Centre for Medium-range Weather Forecasts
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
GEOS	Geostationary
HDF	Hierarchical data Format

HRIT	High Rate Information Transmission
IR	Infrared
LAM	Limited Area Model
MSG	Meteosat Second Generation
NWP	Numerical Weather Prediction
PGE	Product Generation Element
QC	Quality Control
SAF	Satellite Application Facility
SAFNWC	SAF to support NoWCasting and Very-Short-Range Forecasting
SAI	Stability Analysis Imagery
SEVIRI	Spinning Enhanced Visible & Infrared Imager
SUM	Software User Manual
TPW	Total Precipitable Water
WV	Water Vapour

1.6 REFERENCES

1.6.1 Applicable Documents

For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the document referred to applies.

Latest documentation can be found at the SAFNWC Help Desk at http://www.nwcsaf.org

Reference	Title	Code	Vers	Date
[AD. 1]	Interface Control Document for the External and Internal Interfaces of the SAFNWC/MSG	SAF/NWC/CDOP/INM/SW/ICD/1		
[AD. 2]	SAFNWC/MSG Output Products Format Definition	SAF/NWC/CDOP/INM/SW/ICD/3		
[AD. 3]	Software User Manual for the SAFNWC/MSG application	SAF/NWC/CDOP/INM/SW/SUM/2		
[AD. 4]	Algorithm Theoretical Basis Document for the "Air Mass Analysis" product (AMA, PGE12)	SAF/NWC/CDOP/ZAMG/SCI/ATBD/12		
[AD. 5]	Validation Report for “Air Mass Analysis” (AMA-PGE12, v2.1)	SAF/NWC/CDOP/ZAMG/SCI/VAL/3	1.0	29/09/08

Table 1: List of Applicable Documents

1.6.2 Reference Documents

The reference documents contain useful information related to the subject of the project. This reference document complements the applicable documents. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the document referred to applies.

Latest documentation can be found at the SAFNWC Help Desk at http://www.nwcsaf.org

Reference	Title	Code	Vers	Date
[RD.1]	Scientific report on Validation and Tuning of MSG PGE12	SAF/NWC/IOP/ZAMG/SCI/VAL/1	1.0	19/08/05
[RD.2]				

Table 2: List of Referenced Documents

2. DESCRIPTION OF THE AIR MASS ANALYSIS (AMA) PRODUCTS

2.1 GOAL OF THE AIR MASS ANALYSIS (AMA) PRODUCTS

PGE12 of the SAFNWC/MSG provides several products considered useful for air mass analysis. Well-established concepts from literature were taken and implemented/adapted for a use with SEVIRI imagery, supplemented - where necessary - by NWP products:

- A rather classical classification of air masses as function of total precipitable water and temperature derived from satellite data.
- Tongues of equivalent-potential temperature indicate protruding warm and moist air in which severe local convection is most likely to occur (Carlson, 1991; Bader et al., 1995; ZAMG, 2005). Therefore, an objective determination of the ridge lines of the equivalent-potential temperature field is performed.
- Indication of areas where there is high probability for the initiation of convection: the areas at the leading edge of frontal cloud bands. Therefore, the pre-frontal regions with high gradients of equivalent-potential temperature are marked.
- Dry air in the upper troposphere is another air mass type that is important in two respects:
  - Dry air overrunning frontal zones is connected to the development of intensive convection at the leading parts of fronts (ZAMG, 2005).
  - The boundaries between wet and dry air (boundaries between gray and black stripes in WV) are preferred zones for initiation of convection (Martín et al., 1999; ZAMG, 2005).

2.2 OUTLINE OF AIR MASS ANALYSIS (AMA) ALGORITHMS

2.2.1 Air mass classification algorithm outline

The implemented scheme is based on finding reference pixels where IR13.4 "almost certainly" indicates the correct air mass type. The motivation to use IR13.4 is that this is the only IR channel with a weighting function not peaking at the earth's surface, thus mitigating land heating effects. Then the WV7.3 brightness temperature at these pixels together with longitude and (often more importantly) latitude information is subject to multiple linear regression, with air mass type (categories "arctic" to "equatorial" numerically translated to values of a "fractional air mass code" (hereafter FAMC) from 1.0 to 4.0) as the dependent variable.

Under the assumption that equatorial air masses are never adjacent to polar or arctic air and tropical and arctic air masses are always separated by the polar category, the problem becomes one of multifold multiple linear regression applied to the separation sub-problems:

- separation of arctic from polar,
- separation of polar from tropical,
- separation of tropical from equatorial.

After some releases based on the NWCSAF product "total precipitable water" (TPW), v2008 switched over to a NWP-derived TPW. TPW thresholds between continental and maritime air masses are dependent on the numerical values of the functions obtained in the regressions: For

"perfectly" arctic, polar, tropical and equatorial air, the thresholds are respectively 0.48, 1.13, 2.66 and 6.25 cm.

2.2.2 WV dark stripe detection algorithm outline

The detection of dark stripes has the following principal steps:

(1) For each pixel, it is checked whether the pixel is dark enough to be eligible, i.e. whether it is darker than an empirical threshold (brightness temperature has to be ≥-40.5°C).

(2) For each candidate pixel it is verified that it is darker than (most of) its neighbours.

(3) The pixels passing the test undergo postprocessing: a contouring algorithm is applied to encircle sufficiently extended conglomerates of such pixels.

2.2.3 'Ridge line' product algorithm outline

The SAFNWC/AMA package determines the ridge line of the equivalent-potential temperature derived from NWP forecast fields of temperature and humidity as follows:

- Computation of a "pseudo curvature vorticity" which describes the curvature of the NWP 850 hPa equivalent-potential temperature isolines.
- For each point, determination of number of neighbours (N_+) with higher values of "pseudo curvature vorticity" ("less anticyclonic" neighbours). Generally, a point should have $N_+ \geq 6$ in order to be eligible. However, it can be shown (and justified) that occasionally also points with $N_+=4$ or $N_+=5$ need to be taken into account. A negative "pseudo curvature vorticity" is a natural further prerequisite for eligibility. Then, a ridge of the function is tracked by:
- repeated determination of the direction of smallest descent of the N_+ function, starting from a local minimum.

2.2.4 Gradient zone product algorithm outline

Main criterion for indicated gradient zone: sufficiently extended zone of gradient above an empirical threshold; either the gradient's x-component or y-component has to have the same sign all over the indicated zone (otherwise two gradient zones would be joined which for geometrical reasons are unlikely to represent the same prefrontal region). The product is "cleaned" in such a manner that gradient zone markers are withdrawn in regions where the SAFNWC/MSG cloud mask reports clouds (in those areas, the product shows pixel values of an IR channel). Note that the "large-scale" check on the gradient zone comes first, i.e. due to cloud masking, some small patches of indicated gradient may appear in the final product.

2.3 DESCRIPTION OF AIR MASS ANALYSIS (AMA) OUTPUTS

This product consists of several sub-products with different output format:

(1) The air mass classification product (AMA_CL) provides air mass designations at pixel resolution. The product format is HDF5**.** From v2008 on, the "gradient zone of the NWP equivalent-potential temperature field" product is an image-like product packed into the same HDF5 file (product code AMA_GZ). There is moreover a quantity AMA_QUALITY, which represents a quality flag implemented in a first version in v2009 and possibly to be augmented in subsequent releases.

The number of air mass classes in the current version (PGE12 of SAFNWC/MSG release v2010) is 9 or 17 (depending on whether the user turns the SAI inclusion option off or on) +8

placeholders for possible future use, with the following coding (if SAI inclusion is not selected or the SAI product is missing, the lower numbers are selected and classes 13 to 24 do not appear):

Code	Name
0	unclassified
1	Arctic, continental, stable
2	(Arctic, reserved for future use)
3	Arctic, maritime, stable
4	Polar, continental, stable
5	(Polar, reserved for future use)
6	Polar, maritime, stable
7	Tropical, continental, stable
8	(Tropical, reserved for future use)
9	Tropical, maritime, stable
10	Equatorial, continental, stable
11	(Equatorial, reserved for future use)
12	Equatorial, maritime, stable
13	Arctic, continental, unstable
14	(Arctic, reserved for future use)
15	Arctic, maritime, unstable
16	Polar, continental, unstable
17	(Polar, reserved for future use)
18	Polar, maritime, unstable
19	Tropical, continental, unstable
20	(Tropical, reserved for future use)
21	Tropical, maritime, unstable
22	Equatorial, continental, unstable
23	(Equatorial, reserved for future use)
24	Equatorial, maritime, unstable

The parameter AMA_QUALITY has a range of 0-4 with the folowing meanings:

Code	Meaning
0	no QC possible because pixel cloudy in at least one of the considered AMA_CL fields
1	no change in thermal category (i.e. arctic, polar, tropical or equatorial) and moisture category (maritime vs. continental) between current and previous slot
2	change in moisture category
3	change in thermal category
4	change in both moisture and thermal category

Note that this parameter may be missing in the HDF output file (namely if there is no precursor product, in which case the impossibility of a quality check is also verbally reported (in the log files)).

The gradient zone product has 128 different count values with the following meaning:

Code	Name
0	cloudfree, no gradient zone identified
1	cloudfree, gradient zone identified
2-127	cloudy; information on gradient zone not relevant (since only of significance in prefrontal areas); IR greyscale image shown instead (taken from the 13.4 micron channel)

The names of the output files adhere to the SAFNWC/MSG convention on HDF5 file naming.

(2) Additionally, the coordinates of special lines are provided. In order to provide the user with the utmost flexibility, these lines are not super-imposed on the image but are described in separate BUFR files; the used BUFR edition is No. 4. The employed naming convention mimics the SAFNWC system for BUFR format files to the extent possible (it actually adds only the designation of the sub-product: a) dark stripes in WV imagery: "WVstripe" b) ridge lines of the equivalent-potential temperature field:"T-Ridge".

Field Name	Description	Data Type	Value
Product_id (1)	Identifier for SAFNWC	6 char.	"SAFNWC"
Field Separator	Separator	1 char.	"_" (underscore)
Product_id (2)	Spacecraft identifier	4 char.	"MSG*i*" (where *i* is an integer)
Field Separator	Separator	1 char.	"_" (underscore)
Product_id (3)	product name	4 char.	The PGE-specific code "AMA_".
Field Separator	Separator	1 char.	"_" (underscore)
Product_id (4)	Date/time of acquisition of SEVIRI image	12 char.	"yyyymmddhhmm"
Field Separator	Separator	1 char.	"_" (underscore)
Product_id(5)	Name of processed region	12 char.	Taken from the entry under REGION in the region configuration file and padded by underscores where needed.
Field Separator	Separator for extension	1 char.	"."
Product_id(6)	Name of sub-product	variable number of char.	Name of the sub-product coded in the BUFR file. One of the following: "WVstripe", "T-Ridge"
Field Separator	Separator for extension	1 char.	"."
Extension	Extension of the product name to indicate the type of data	3 char.	buf

Table 3: File name components of AMA BUFR output

The template of the BUFR files is as follows:

101000 SPECIFICATION OF THE REPLICATION
031002 EXTENDED DELAYED DESCRIPTOR REPLICATION FACTOR
301023 expands to:
    005002 LATITUDE (COARSE ACCURACY)
    006002 LONGITUDE (COARSE ACCURACY)
011021 RELATIVE VORTICITY[1]

The output files contain as many BUFR records as there are identified black stripes or ridge lines, respectively.

[1] This entry appears only in the ridge line product. The product derivation starts with the computation of a "pseudo curvature vorticity" which describes the curvature of the NWP 850 hPa equivalent-potential temperature isolines. The internal absolute value of this quantity at the starting point of the ridge line tracking (=a local maximum of anticyclonicity) is provided. It should be a measure how distinctive the pattern is (and therefore can be exploited to filter weakly developed ridges (via a user-set keyword in the PGE12 model configuration file)).

3. IMPLEMENTATION OF AIR MASS ANALYSIS (AMA)

AMA is extracted by PGE12 of the SAFNWC/MSG software package. Detailed information on how to run this software package are available in the "Software User Manual for the SAFNWC/MSG application" [AD. 3].

The implementation of the PGE12 software follows the general implementation of components of the SAFNWC/MSG software (see the software part of the Software Users Manual of the SAFNWC/MSG software for more details).

Basically, the following steps are needed to run the PGE12 software:

1. Create or update configuration files (system, region, model and run configuration files) according to their format (see the Interface Control Document ICD/1 for the External and Internal Interfaces of the SAFNWC/MSG). Files are situated in $SAFNWC/config.
2. Algorithm configuration files are situated in the directory "$SAFNWC/import/Aux_data/PGE12". These PGE12 input files are provided with the software package, installed together with it, and are not foreseen for modification by users.
3. The cloud mask (CMa) input (which is the output of PGE01 of the SAFNWC/MSG) matching slot and region has to be made available in the directory "$SAFNWC/export/PGE01"
4. Provided the user requested the inclusion of optional stability analysis imagery (SAI) input, which is the output of PGE08 of the SAFNWC/MSG, SAI data matching slot and region have to be made available in the directory "$SAFNWC/export/PGE08"
5. For producing the products based on NWP data, the reprocessed NWP data have to be available in the DATABUF directory "$SAFNWC/tmp".
6. Ensure that the SEVIRI image file in HRIT format (mandatory input) is available in the directory $SAFNWC/import/SEVIRI_data/.
7. Make sure that the environment variable $SAFNWC is set. The environment variables $BUFR_TABLES and $LOCAL_DEFINITION_TEMPLATES need also be set (as $SAFNWC/src/bufr_000360/bufrtables/ and $SAFNWC/src/gribex_000360/gribtemplates/, respectively)
8. Make sure that the following supplementary files are available:
   a) $SAFNWC/src/bufr_000360/bufrtables/B0000000000098002001.TXT,
   b) $SAFNWC/src/bufr_000360/bufrtables/D0000000000098002001.TXT,
   c) $SAFNWC/import/Aux_data/Topo_+000.00.dat (for METEOSAT-8: Topo_+009.50.dat)

   These files are not included in the PGE12 distribution because they are packed into other libraries also delivered with SAFNWC/MSG. The listed files should be available after unpacking the full SAFNWC/MSG SW package, as described in the relevant documentation.

Then, the processing of PGE12 is automatically monitored by the task manager (see the Software Users Manual for the Task Manager of the SAFNWC/MSG software).

Submitting PGE12 in stand-alone mode, not using the task manager:

Ensure that all required input data are available in their respective directories, and that pre-requirements listed under items 1-8 are fulfilled.

PGE12 can be called as follows (from the directory where it is situated):

./PGE12 YYYYMMDDhhmm region_configuration_file model_configuration_file

Example:
./PGE12 200303281145 myregion.cfg safnwc_pge12.cfm

4. INPUTS AND CONFIGURABLE PARAMETERS FOR AIR MASS ANALYSIS (AMA)

4.1 LIST OF INPUTS

4.1.1 Air mass classification product

- SEVIRI IR imagery, channels 7.3 and 13.4
- NWP information (temperature und humidity information in various levels) in DATABUF format (as preprocessed by the SAFNWC/MSG application)
- SAFNWC/MSG product Cloud mask, which is the output of PGE01 of the SAFNWC/MSG
- Optionally: Stability analysis imagery (SAI), which is the output of PGE08 of the SAFNWC/MSG

4.1.2 WV dark stripe product

- SEVIRI WV image, channel 6.2

4.1.3 'Ridge line' product

- ECMWF NWP GRIB data (temperature und humidity information in 850hPa).

4.1.4 'Gradient zone of equivalent-potential temperature' product

- ECMWF NWP data (temperature und humidity information in 850hPa) in DATABUF format (as preprocessed by the SAFNWC/MSG application)
- SEVIRI IR imagery, channel 13.4
- SAFNWC/MSG product Cloud mask, which is the output of PGE01 of the SAFNWC/MSG

4.2 CONFIGURABLE PARAMETERS FOR AIR MASS ANALYSIS (AMA)

The configurable parameters can be found in the model configuration file for the PGE12, which is separated into two parts. The first section contains three parameters that can be set by the user (Then, starting with the entry PGE_ID, the rest of the model configuration file is constituted by a section that should be touched only by the institute responsible for development/maintenance of PGE12, which at present is ZAMG.)

Keyword	Description	Type	Possible Value(s)
INCORPORATE_SAI	Decide whether the NWCSAF SAI product should be incorporated in the AMA air mass classification process.	chain of characters	YES or NO
RL.MinLength	The minimum length in terms of NWP grid points a ridge line has to have in order to appear in the output	integer	all (yet values <2 are set to 2 internally)
RL.MinAbsCurvature	The minimum anticyclonic curvature an extremum has to have in order to be eligible as a starting point of a ridge-line tracking	float	all (yet values < 0. are set to 0. internally)

The first entry is straightforward to set (see also section 2.3). The other two parameters define the filtering of the ridge line product. From v2008 on, this product takes the NWP GRIB file provided by the user in $SAFNWC/import/NWP_data as it is, and analyzes ridge lines on the NWP grid. Thereby, LAM output became permissible as input; on the other hand, this means that the

developers can no longer control the meaning of "significant ridge lines" in terms of length of the ridge line and curvature of the isolines. Length and curvature are encoded in the BUFR telegrams (see section 2.3) and the two entries in the model configuration enable the user after some experience with his/her own NWP data to set the filtering parameters appropriately, if wished so. At delivery, the configuration parameters are basically functionless (just reflecting that a line should consist of two points and a ridge is not cyclonic!).

5. AIR MASS ANALYSIS (AMA) VALIDATION

5.1 SUMMARY OF AIR MASS ANALYSIS (AMA) VALIDATION RESULTS

The air mass analysis products face some conceptual difficulties w.r.t. to their validation (described in more detail in the two AMA validation reports [RD.1] and [AD.5]). In this situation, the issues of validation in [AD.5] were subjective judgements on

- whether the indicated ridge lines, stripes… were analysed in a similar fashion as a trained meteorologist would do
- whether these analyses are stable in time.
- whether the analyses are stable against changes in the region selected by a user.

In [RD.1], moreover actually observed cases of convection were used as starting points and it was investigated whether these were somehow predictable from the AMA products.

Most recently, the air mass classification was judged against tropopauses derived from IASI and ATOVS level-2 profiles [AD.5, Test 5]. A slight change of algorithmic thresholds was proposed as a result, and these changes were implemented in v2009.

In summary, based on those subjective evaluations, the products of v2010 give no reason for serious concern. The two sub-products being judged as hardly acceptable in [RD.1] (namely: “air mass classification” and “gradient zone”) saw a complete refurbishment of their concepts, so the criticism expressed in this document today no longer holds.

5.2 TYPICAL KNOWN PROBLEMS AND RECOMMENDATION FOR USE

Pattern recognition routines generally benefit from large analysis area (the more one sees from the surrounding, the more certain is the analysis of the local pattern). It is therefore in principle possible (even though the robustness for the common 512x512-pixel region has been verified) that users select a too small analysis region. Note that the flexibility on the region was introduced in v2008 in response to an (understandable) user request, not on scientific grounds (before that, PGE12 used a large region covering all of Europe and substantial parts of the Atlantic Ocean).

With the tuning process being mainly done on subjective reasoning, a certain risk of differing perception among different individually cannot be ruled out.

Most sub-products of PGE12 are based on the objective recognition of certain patterns that MAY indicate imminent convective activity. None of these features is by itself a trigger of convective activity. In fact, there is no doubt that in the majority of cases or over most of the extension of such a phenomenon, no severe weather is found. Consequently, they have always to be considered in conjunction with other relevant meteorological material, not on their own.

Unfortunately, with respect to setting the configurable parameters for ridge line detection (section 4.2), no guidelines can be presented at the time being, as this option has been introduced only very recently and it is moreover hardly possible to cover all the different NWP input users may provide.

6. EXAMPLES OF AIR MASS ANALYSIS (AMA) VISUALISATION

Figure 1 shows the visualization of the BUFR products: WV stripes and ridge lines of equivalent potential temperature. *Figure 2* gives an example how the air mass classification product may be presented to the user, and *Figure 3* provides a glance on a gradient zone output.

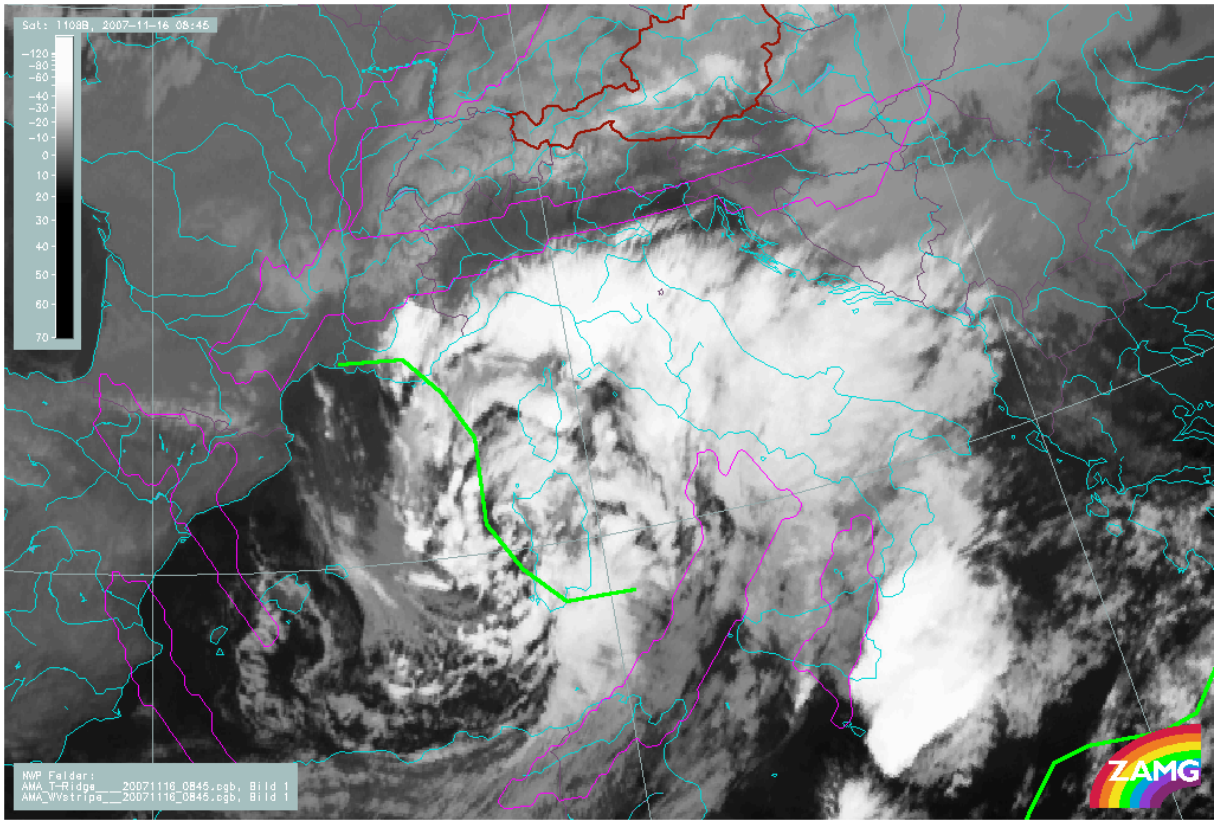

Figure 1: Ridge line detection for an equivalent-potential temperature field (ECMWF forecast data); the green lines indicate the positions of the automatically detected ridge axes. Magenta isolines encircle the WV dark stripes that are identified by the respective part of the SAFNWC AMA package. Case: 16 November 2007, 0845 UTC.

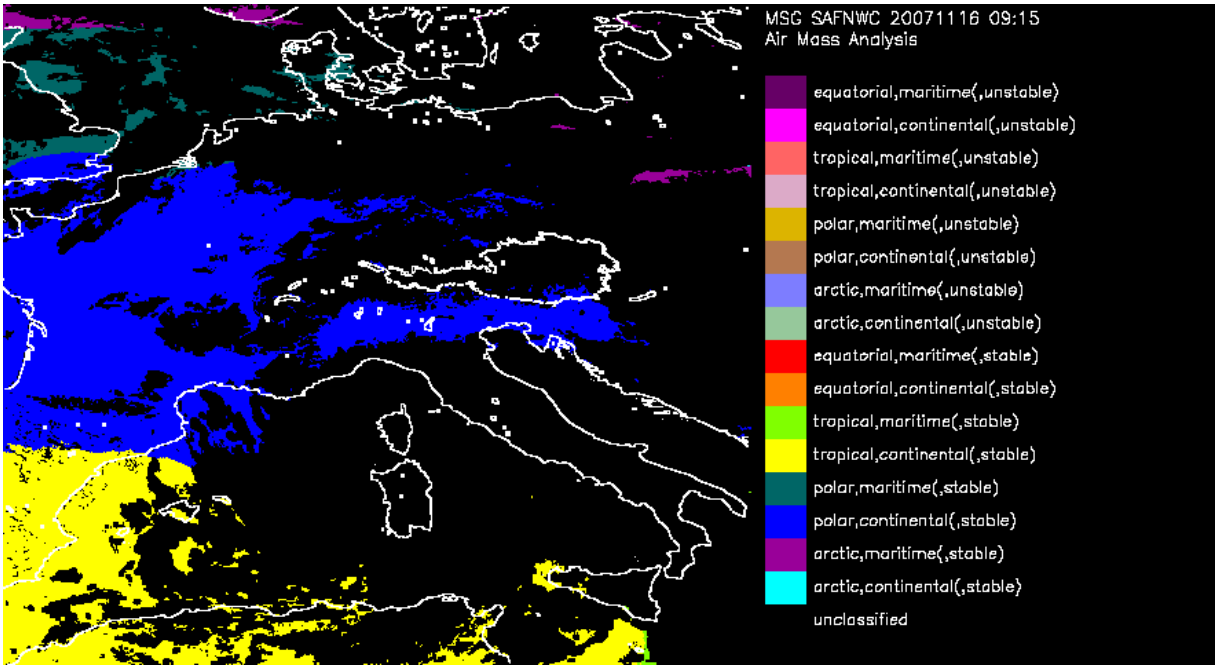

Figure 2: Example display of the SAFNWC air mass classification product. Case of 16 November 2007, 0915 UTC, unclassified cloudy pixels appearing in black. Prevailing on the display is tropical+continental and polar+continental air (see attached colour legend; optional SAI inclusion was turned off).

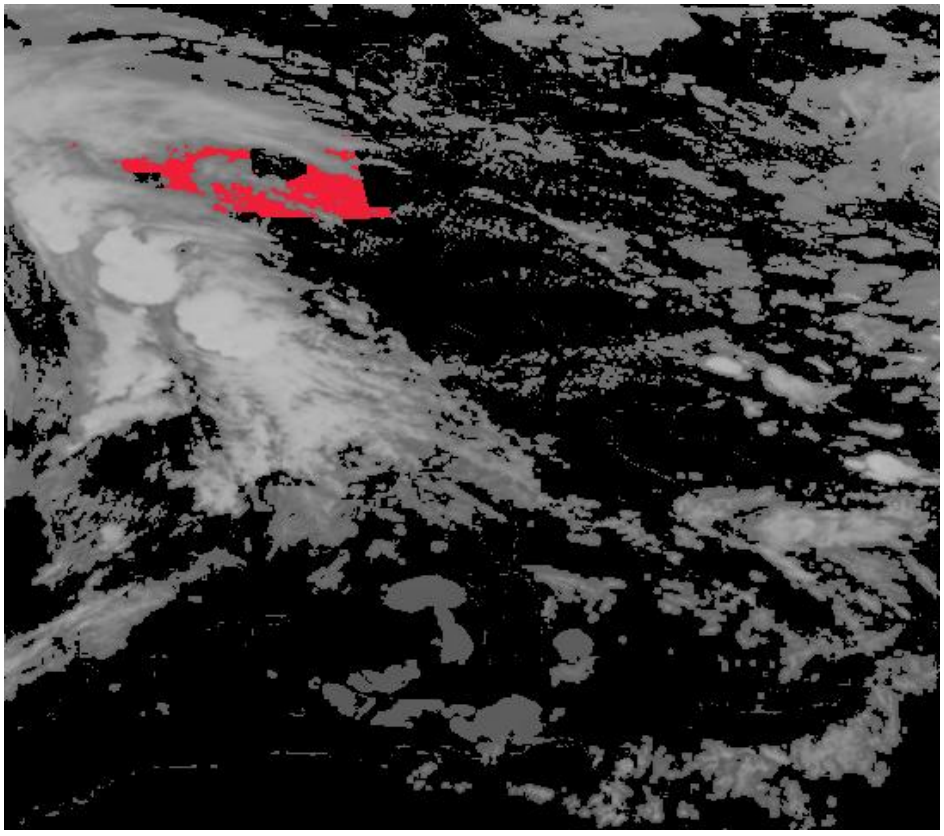

Figure 3: Example display of the SAFNWC gradient zone product, as seen in the HDFView software. Case of 19 June 2007, 1630 UTC, gradient zone painted red, cloudy pixels plotted in greyscale.

For convenience, the source code of the production program that drew the graphics in *Figure 1* is included below. Users are probably most interested in the sections on BUFR decoding, hence these parts are highlighted by boldface printing. Note that the BUFR decoding sections are virtually identical for the two sub-products. The other parts of the program mainly contain commands to accomplish the graphics output by the MAGICS package.

```
C     THIS IS A DEMO BUFR DECODING ROUTINE FOR LONGITUDE/LATITUDE
C     INFORMATION SUBMITTED BY SAFNWC AMA ROUTINES
C     AUTHOR:    ALEXANDER JANN / ZAMG / VIENNA, AUSTRIA
C     CREATION DATE: 13/07/2001
C     THIS IS INTENDED TO REPRESENT A USEFUL SUPPORT TO USERS OF THE
C     SAFNWC/MSG SOFTWARE PACKAGE, BUT COMES WITHOUT WARRANTY OF ANY
C     KIND.

      PROGRAM SAFNWC_AMA_BUFR
      PARAMETER (JSEC0=3, JSEC1=40, JSEC2=64, JSEC3=4, JSEC4=2)
      PARAMETER (JELEM=20000, JSUP=9, JBYTE=80000)
      PARAMETER (KELEM=20000, KVALS=80000, KVALS1=80000)

      DIMENSION KBUFF(20000), KSUP(JSUP)
      DIMENSION KSEC0(JSEC0),KSEC1(JSEC1),KSEC2(JSEC2),KSEC3(JSEC3)
      DIMENSION KSEC4(JSEC4)
#ifndef R_4
      REAL*8 VALUES(KVALS1)
#else
      REAL VALUES(KVALS1)
#endif
      DIMENSION CONTOURX(20000),CONTOURY(20000),MARKSYM(20000)
      CHARACTER*80 CVALS(KVALS), CGBNAMEINTRO, EXPORT_PATH
      CHARACTER*24 CUNITS(KELEM)
      CHARACTER*64 CNAMES(KELEM)
      CHARACTER*255 MM
      DATA MARKSYM / 20000*1 /

      CGBNAMEINTRO='SAFNWC_MSG1_AMA__00160_024_Region_ZAMG_.'
      N=GETENV('SAFNWC',EXPORT_PATH)
      EXPORT_PATH=EXPORT_PATH(1:INDEX(EXPORT_PATH,' ')-
1)//'/export/PGE12/'
      INDEXPO=INDEX(EXPORT_PATH,' ')-1

C     OPEN MAGICS, DEFINE GRAPHICAL DEVICE AND FIX GEOGRAPHICAL AREA

      CALL POPEN
      CALL PNEW ('SUPER_PAGE')
      CALL PNEW ('PAGE')
      CALL PSETI ('WORKSTATION_COUNT',1)
      CALL PSETC ('WORKSTATION_1','CGM_BINARY')
      CALL PSETC ('PAGE_FRAME','OFF')
      MM = 'MAGICS_METAFILE='//EXPORT_PATH(1:INDEXPO)//'T-Ridge.cgb'
      JI = PUTENV(MM)
      CALL PSETC ('SUPER_PAGE_FRAME','ON')
      CALL PSETR ('SUPER_PAGE_X_LENGTH',29.7)
      CALL PSETR ('SUPER_PAGE_Y_LENGTH',24.0)
      CALL PSETR ('PAGE_X_LENGTH',29.7)
      CALL PSETR ('PAGE_Y_LENGTH',24.0)
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      CALL PSETC ('SUBPAGE_MAP_PROJECTION','POLAR_STEREOGRAPHIC')
      CALL PSETC ('SUBPAGE_MAP_AREA_DEFINITION','CORNERS')
      CALL PSETR ('SUBPAGE_MAP_VERTICAL_LONGITUDE',0.0 )
      CALL PSETR ('SUBPAGE_LOWER_LEFT_LONGITUDE',-29.5)
      CALL PSETR ('SUBPAGE_LOWER_LEFT_LATITUDE', 22.6)
      CALL PSETR ('SUBPAGE_UPPER_RIGHT_LONGITUDE',73.1)
      CALL PSETR ('SUBPAGE_UPPER_RIGHT_LATITUDE', 56.3)
      CALL PSETR ('SUBPAGE_X_POSITION',2.23)
      CALL PSETR ('SUBPAGE_Y_POSITION',1.05)
      CALL PSETR ('SUBPAGE_X_LENGTH',22.41)
      CALL PSETR ('SUBPAGE_Y_LENGTH',17.85)

C     !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
C     DECODE BUFR FILE CONTAINING THE SAFNWC/AMA-'RIDGE LINE OF
C     EQUIVALENT-POTENTIAL TEMPERATURE' PRODUCT
C     !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

      IRET=0
      CALL PBOPEN (IUNIT,EXPORT_PATH(1:INDEXPO)//
     +  CGBNAMEINTRO(1:INDEX(CGBNAMEINTRO,'.'))//'T-
Ridge.buf','r',IRET)
      IF (IRET .NE. 0) GOTO 13

      KERR=0
      IRET=0
      KBUFL=0

11    CONTINUE

C     EXTRACT COORDINATES OF ONE RIDGE LINE

      CALL PBBUFR (IUNIT,KBUFF,JBYTE,KBUFL,IRET)
      IF (IRET .EQ. -1) GOTO 13
      KBUFL=KBUFL/4+1
      KEL=KELEM
      CALL BUFREX (KBUFL,KBUFF,KSUP,KSEC0,KSEC1,KSEC2,KSEC3,KSEC4,
     +  KEL,CNAMES,CUNITS,KVALS,VALUES,CVALS,KERR)

      IF (KERR .NE. 0) THEN
           WRITE(6,*) 'ERROR DURING DECODING'
           GOTO 13
      END IF

C     COPY THE LONGITUDE AND LATITUDE VALUES TO CONTOURX AND
CONTOURY,
C     RESPECTIVELY
C     (STRUCTURE OF "VALUES": REPLICATION FACTOR, LAT, LONG, LAT,
C     LONG,...)

      DO 12 K=1,VALUES(1)
           CONTOURY(K)=VALUES(2*K)
           CONTOURX(K)=VALUES(2*K+1)
12    CONTINUE

C     PLOT THE RIDGE LINE
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      CALL PSETC ('GRAPH_POSITION_MODE','GEOGRAPHIC')
      CALL PSETC ('GRAPH_LINE_STYLE','SOLID')
      CALL PSETC ('GRAPH_TYPE','CURVE')
      CALL PSETC ('GRAPH_CURVE_METHOD','ROUNDED')
      CALL PSETC ('GRAPH_CURVE_INTERPOLATION','SPLINE')
      CALL PSETI ('GRAPH_SMOOTHING_FACTOR',1)
      CALL PSET1R ('GRAPH_CURVE_X_VALUES',CONTOURX(1:K-1),K-1)
      CALL PSET1R ('GRAPH_CURVE_Y_VALUES',CONTOURY(1:K-1),K-1)
      CALL PSETC ('GRAPH_LINE_COLOUR','GREEN')
      CALL PSETI ('GRAPH_LINE_THICKNESS',3)
      CALL PGRAPH

      GOTO 11    ! NEXT RIDGE LINE

C     CLOSE BUFR FILE, CLOSE MAGICS, GO ON TO NEXT PRODUCT

13    CALL PBCLOSE(IUNIT,IRET)
      CALL PCLOSE

C=====================================================================
C=====================================================================
C=====================================================================

C     RE-OPEN MAGICS, DEFINE GRAPHICAL DEVICE AND FIX GEOGRAPHICAL
AREA

      CALL POPEN
      CALL PSETI ('WORKSTATION_COUNT',1)
      CALL PSETC ('WORKSTATION_1','CGM_BINARY')
      CALL PSETC ('PAGE_FRAME','OFF')
      MM = 'MAGICS_METAFILE='//EXPORT_PATH(1:INDEXPO)//'WVstripe.cgb'
      JI = PUTENV(MM)
      CALL PSETC ('SUPER_PAGE_FRAME','ON')
      CALL PSETR ('SUPER_PAGE_X_LENGTH',29.7)
      CALL PSETR ('SUPER_PAGE_Y_LENGTH',24.0)
      CALL PSETR ('PAGE_X_LENGTH',29.7)
      CALL PSETR ('PAGE_Y_LENGTH',24.0)
      CALL PSETC ('SUBPAGE_MAP_PROJECTION','POLAR_STEREOGRAPHIC')
      CALL PSETC ('SUBPAGE_MAP_AREA_DEFINITION','CORNERS')
      CALL PSETR ('SUBPAGE_MAP_VERTICAL_LONGITUDE',0.0 )
      CALL PSETR ('SUBPAGE_LOWER_LEFT_LONGITUDE',-29.5)
      CALL PSETR ('SUBPAGE_LOWER_LEFT_LATITUDE', 22.6)
      CALL PSETR ('SUBPAGE_UPPER_RIGHT_LONGITUDE',73.1)
      CALL PSETR ('SUBPAGE_UPPER_RIGHT_LATITUDE', 56.3)
      CALL PSETR ('SUBPAGE_X_POSITION',2.23)
      CALL PSETR ('SUBPAGE_Y_POSITION',1.05)
      CALL PSETR ('SUBPAGE_X_LENGTH',22.41)
      CALL PSETR ('SUBPAGE_Y_LENGTH',17.85)

C     !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
C     DECODE BUFR FILE CONTAINING THE SAFNWC/AMA-'DARK STRIPE OF
C     WATER VAPOUR IMAGE' PRODUCT
C     !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

      IRET=0
      CALL PBOPEN (IUNIT,EXPORT_PATH(1:INDEXPO)//
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     +  CGBNAMEINTRO(1:INDEX(CGBNAMEINTRO,'.'))//'WVstripe.buf',
     +  'r',IRET)

      IF (IRET .NE. 0) GOTO 33   ! ERROR IN PBOPEN

      KERR=0
      IRET=0
      KBUFL=0

31    CONTINUE

C     EXTRACT COORDINATES OF ONE BLACK STRIPE

      CALL PBBUFR (IUNIT,KBUFF,JBYTE,KBUFL,IRET)
      IF (IRET .EQ. -1) GOTO 33  ! EOF
      KBUFL=KBUFL/4+1
      KEL=KELEM
      CALL BUFREX (KBUFL,KBUFF,KSUP,KSEC0,KSEC1,KSEC2,KSEC3,KSEC4,
     +  KEL,CNAMES,CUNITS,KVALS,VALUES,CVALS,KERR)

      IF (KERR .NE. 0) THEN
           WRITE(6,*) 'ERROR DURING DECODING'
           GOTO 33
      END IF

C     COPY THE LONGITUDE AND LATITUDE VALUES TO CONTOURX AND
C     CONTOURY, RESPECTIVELY
C     (STRUCTURE OF "VALUES": REPLICATION FACTOR, LAT, LONG, LAT,
C     LONG,...)

      DO 32 K=1,VALUES(1)
           CONTOURY(K)=VALUES(2*K)
           CONTOURX(K)=VALUES(2*K+1)
32    CONTINUE


C     PLOT THE BLACK STRIPE

      CALL PSETC ('GRAPH_POSITION_MODE','GEOGRAPHIC')
      CALL PSETC ('GRAPH_LINE_STYLE','SOLID')
      CALL PSETC ('GRAPH_TYPE','CURVE')
      CALL PSETC ('GRAPH_CURVE_METHOD','ROUNDED')
      CALL PSETC ('GRAPH_CURVE_INTERPOLATION','SPLINE')
      CALL PSETI ('GRAPH_SMOOTHING_FACTOR',1)
      CALL PSET1R ('GRAPH_CURVE_X_VALUES',CONTOURX(1:K-1),K-1)
      CALL PSET1R ('GRAPH_CURVE_Y_VALUES',CONTOURY(1:K-1),K-1)
      CALL PSETC ('GRAPH_LINE_COLOUR','MAGENTA')
      CALL PSETI ('GRAPH_LINE_THICKNESS',1)
      CALL PGRAPH

      GOTO 31    ! NEXT STRIPE

C     CLOSE BUFR FILE, CLOSE MAGICS

33    CALL PBCLOSE(IUNIT,IRET)
      CALL PCLOSE
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END

7. REFERENCES

Bader, M.J., Forbes, G.S., Grant, J.R., Lilley, R.B.E., and Waters, A.J. (Eds.) (1995): Images in weather forecasting. Cambridge University Press, Cambridge.

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ZAMG (2005): Manual of synoptic satellite meteorology: Conceptual models. CD-ROM, version 6.0 (available from ZAMG and online on http://www.zamg.ac.at/docu/Manual/start.htm).